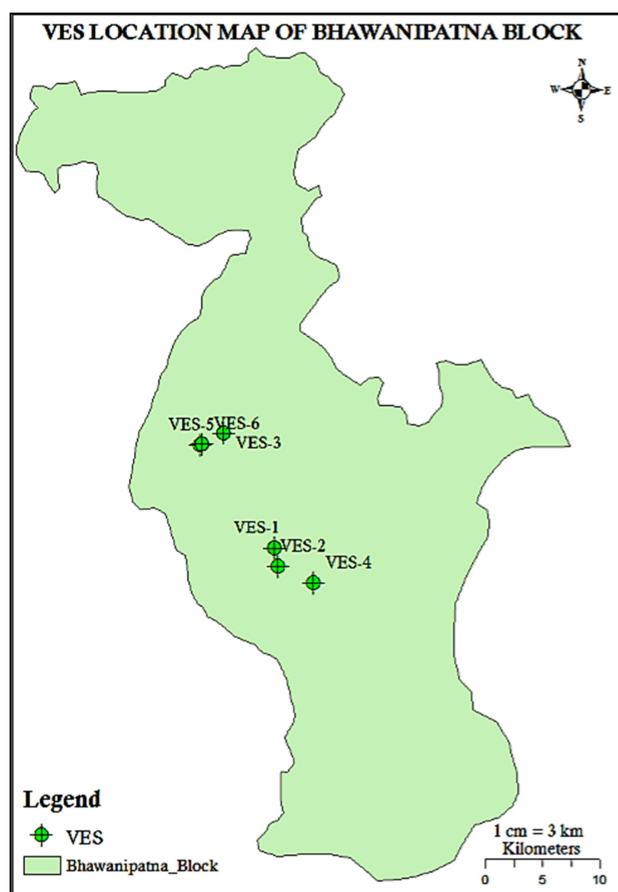


REPORT NO. ARO-RNC/GWI/AROBBSR/2018/03/236

GROUNDWATER INVESTIGATION REPORT

Around Bhawanipatna Block of Kalahandi district, Odhisa
For drinking purpose [Tube Well Site, 15 Locations]



Period of Investigation: 13-16/01/2017, Field Area Visit: to 17-19/01/2017

Implementing Organization



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Last but not the least I thankfully acknowledge to all other people who co-operated & helped directly or indirectly during the period of investigation work.

With best regards & wishes for the consecutively running of the project and good future endeavour at all.

Pradeep Kr. Oraon

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REPORT NO. ARORNC/GWI/AROBBSR/2017/227

GROUNDWATER INVESTIGATION

Tube Well Site, 15 Locations-Drinking Purposes

1. INTRODUCTION:

Request received from AFPRO, Regional Office, Bhubaneswar, to conduct Groundwater Investigation to find out the feasible/suitable sites for drilling bore wells for installation of Hand Pumps for safe drinking water for the community. The present project is funded by HDFC bank to enhance the living standard of the rural people by holistic approach, planning and management. Groundwater Investigation is conducted during 21-26/05/2018 by jointly incorporation of the regional office, Ranchi and Bhubaneswar.

Funding Agency	: HDFC Bank
Project Implementing Organisation	: AFPRO Regional office, Bhubaneswar
Study Conducted by	: Jointly conducted with AFPRO, Regional Office, Ranchi
Represented by ARO Team	: Mr. Ranjit Mohanty & Mr. Pratap Kr. Sahoo Technical Assistants, ARO- Bhubaneswar, Orissa : Dr. Pradeep Kr. Oraon Hydrogeologist, ARO, Ranchi, Jharkhand

1.1. Beneficiary:

Mostly Oria tribal are living in the project villages. More than 400 family/2000 people will be getting safe drinking water from the installed hand pumps.

1.2. Location & Accessibility:

Project villages are located around **Bhawanipatna block** of Kalahandi district in Odhisa. The area of ground water investigation is located approximately 10 to 20 kms away from the Bhawanipatna and is connected partly by metalled, non-metalled and cart track road.

Kalahandi is one of the economically backward district of western Orissa with a geographical area of 7920 Sq. Km and is an integral part of Western Orissa Development Council constituted by Govt. of Orissa very often reels under severe drought condition. About 92.5% percent of the population of the district live in rural areas and agriculture is the main stay of the people. The agriculture is mostly rainfed and due to lack of adequate irrigation facilities and recurring severe drought conditions in the district, the agricultural production is very often curtailed. In the year 1974, 1998, 1999 the district witnessed an unprecedented drought situation.

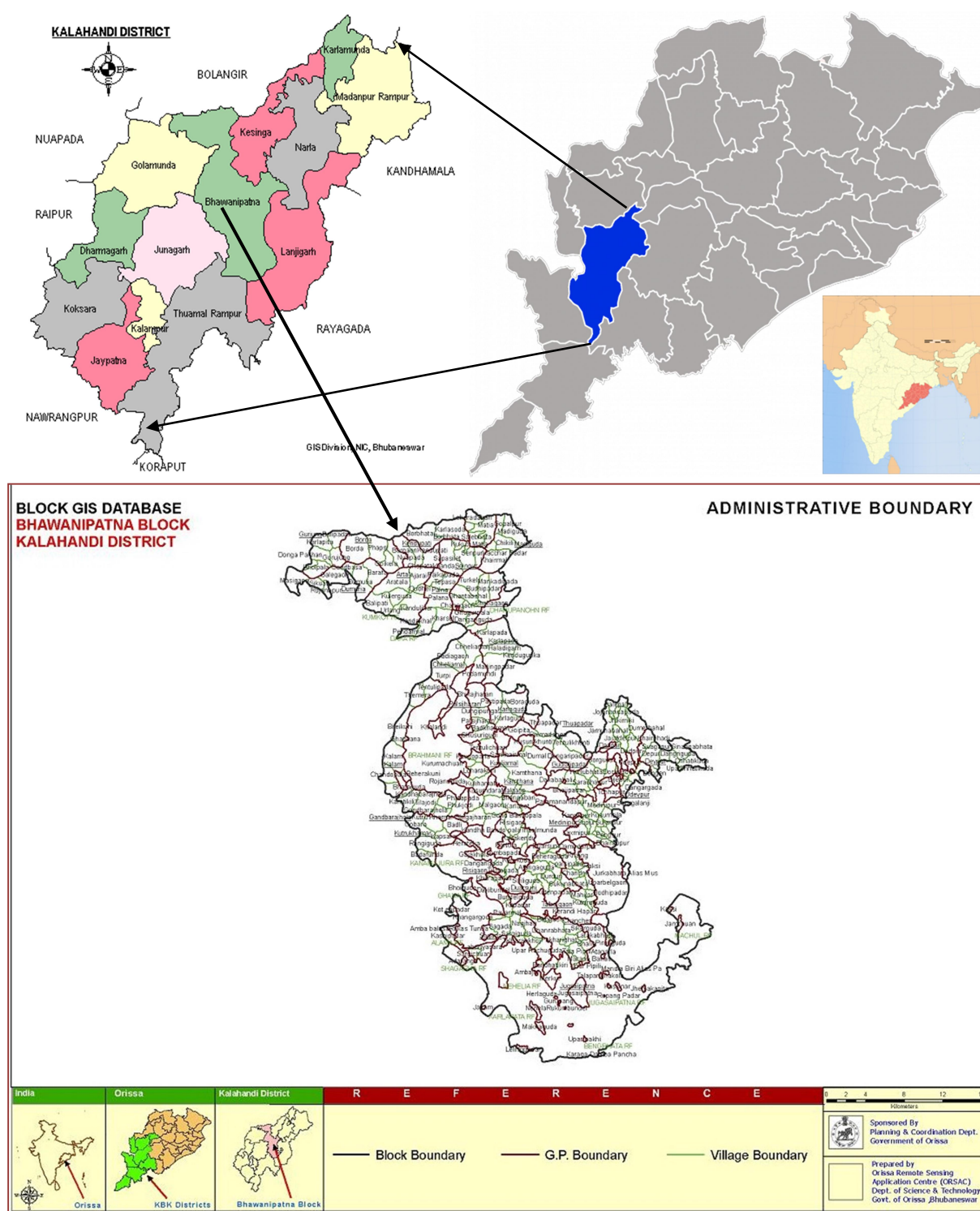


Fig.1. Location map of Bhawanipatna block of Kalahandi district.

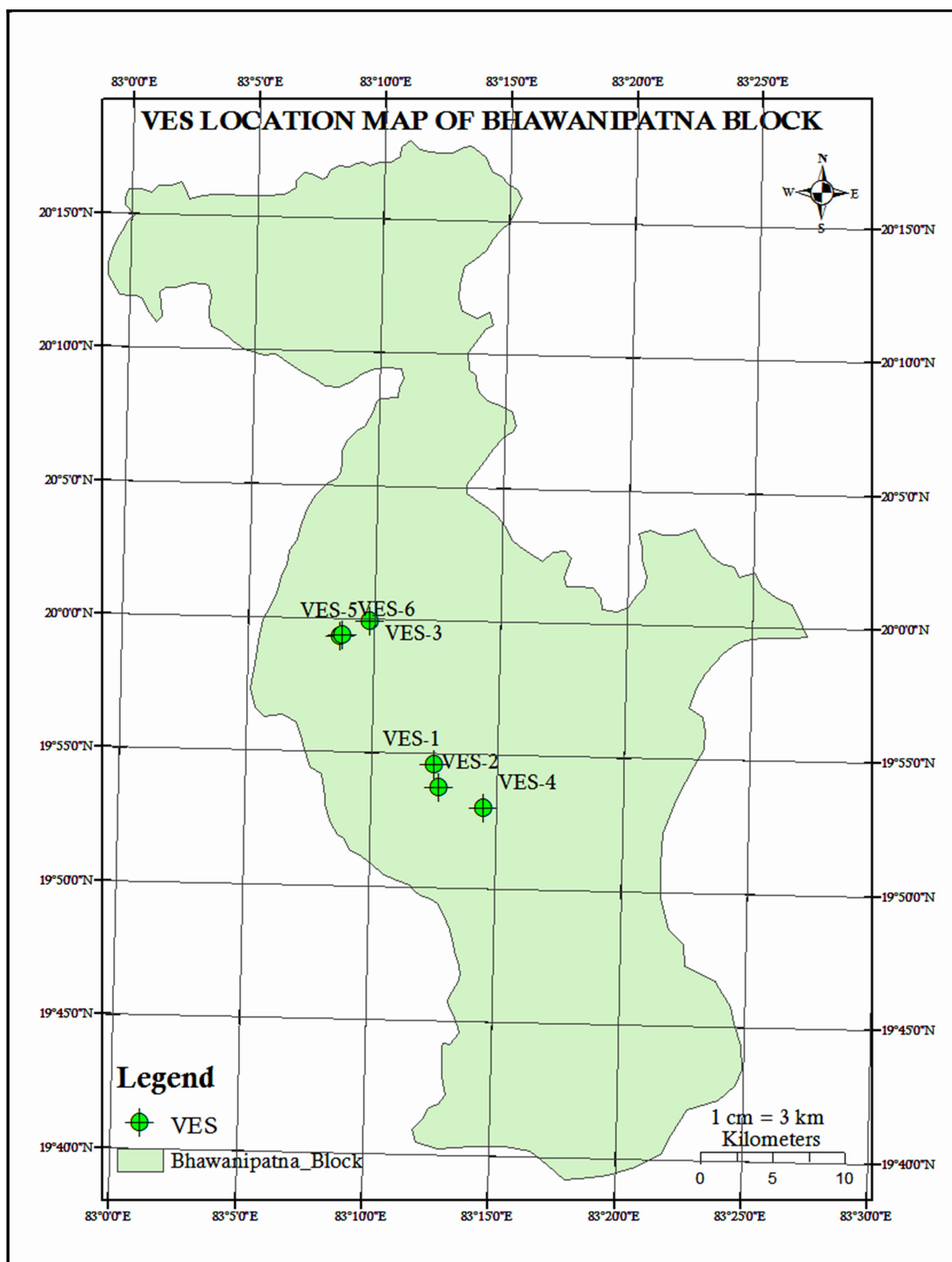


Fig.2. VES Location map of Bhawaniapatna block of Kalahandi district is to be developed.

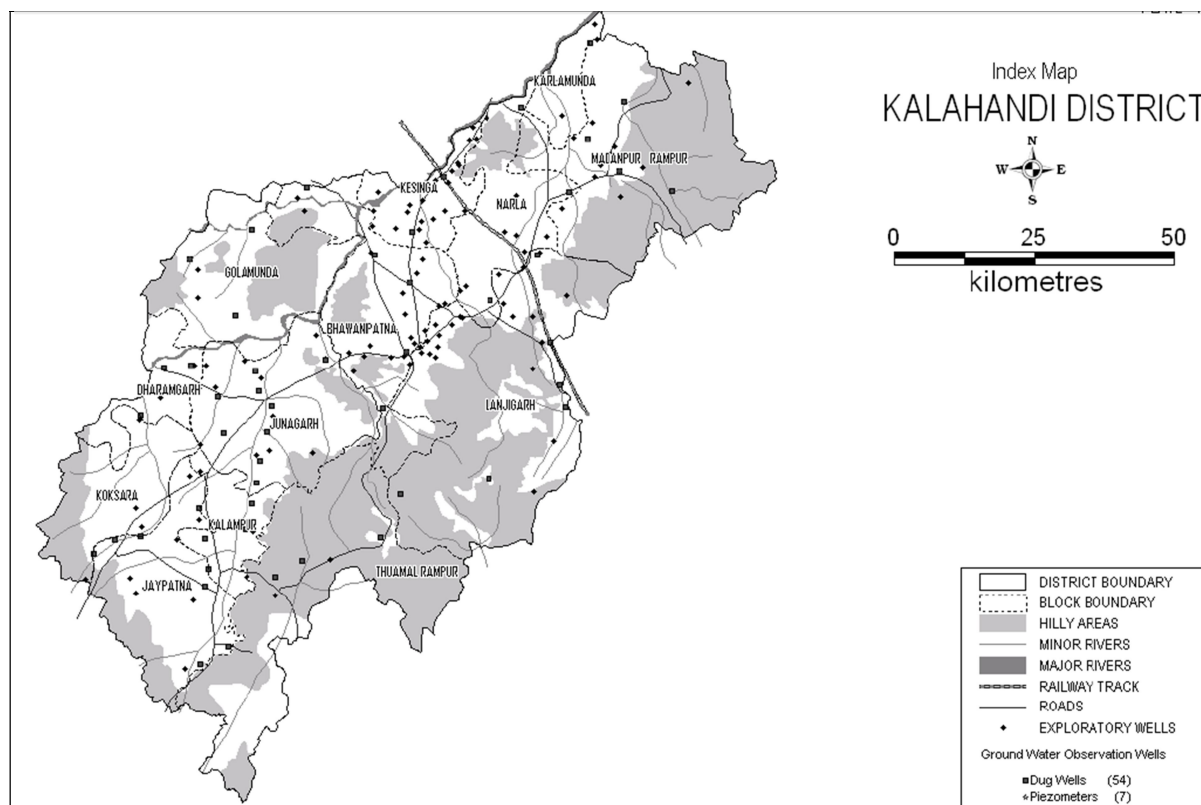


Fig. 3. Physiographic map of Kalahandi district.

2. GEOGRAPHY

Kalahandi district lies between North latitudes 19°03' and 20°45' and East longitudes 82°18' and 83°48', falling in Survey of India toposheet nos. 64 L, 64P, 65 I and 65 M. It is bounded on the north by Balangir and Nuapada districts, on the east by Phulbani district, on the south by Koraput district and on the west by Nawarangpur district of Orissa and Raipur district of Chhattisgarh. The district is well connected by rail and roads.

The district headquarters is at **Bhawanipatna**. The river **Tel** and its tributaries constitute the main drainage system in the district. Other notably rivers are Indravati, Udanti, Hati, Utei, Sagada, Rahul, Nagabali, Mudra, etc.

3. GEO-MORPHOLOGY:

3.1 Topography

The study area is generally considered to be undulating topography with little forest, vegetation and the area is devoid of plain of schistosity. Physiographically the district comprises diverse landforms consisting of rugged hill ranges, plateaus, undulating plains dotted with residual hills and mounds and fertile erosional plains and valleys. A gently undulating terrain with a vast stretch of cultivable land characterizes the major parts west of **Bhawanipatna** in the district. The elevation of the hills located in the southeastern and southern parts ranges from 953 to 1229 m above mean sea level. Kalahandi is surrounded by hills. In Bhawanipatna – Utkela – Kesinga tract the elevation of land surface ranges from

186 m to 350 m above MSL with occasional isolated hills. In the undulating plains the general topographic slope is towards northeast. About eight kilometers south-east of Bhawanipatna commences the mountain tracts called Dongri which covers a vast area of about 3665 sq. kms. on the eastern side of the district and extend southwards to the Koraput border. These tracts rise in a series of precipitous hill ranges from the plains.

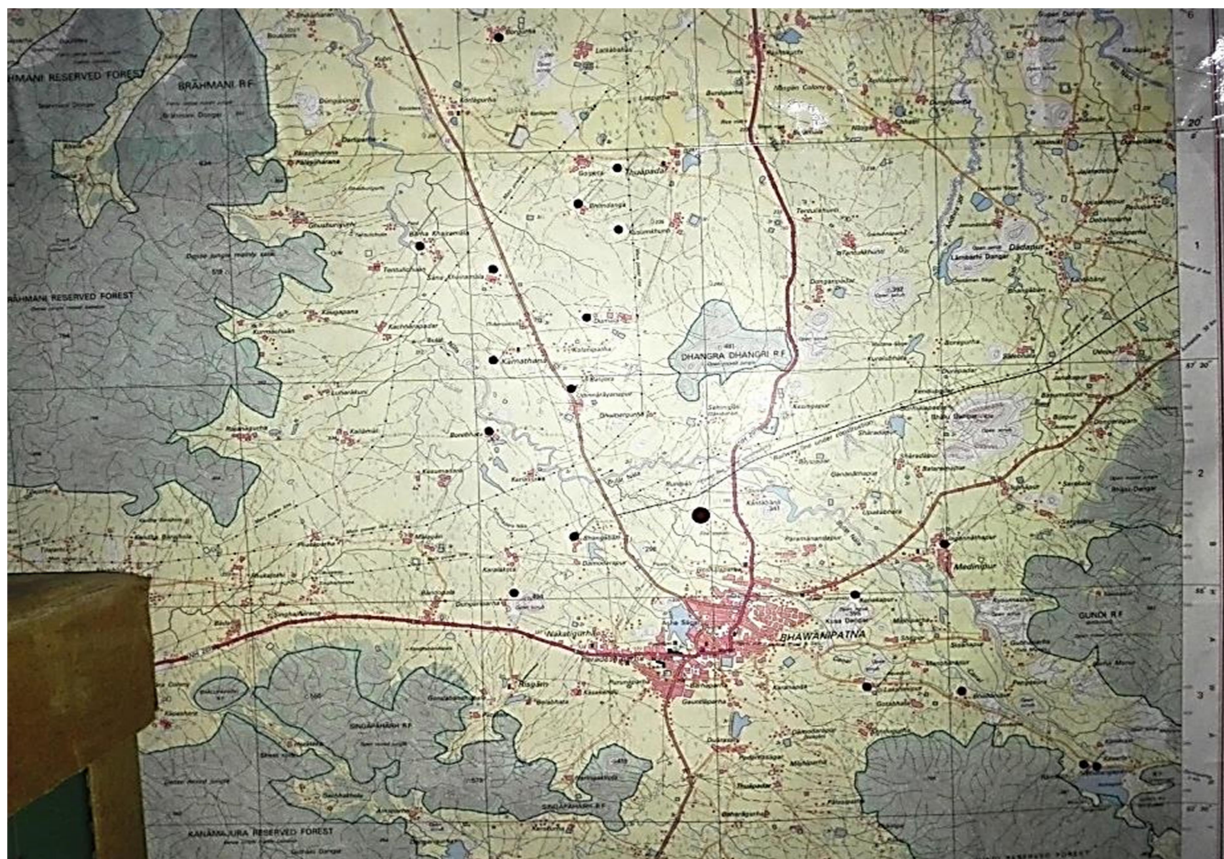


Fig.4. Toposheet of Bhawanipatna, Kalahandi district

3.2 Climate and rainfall

The climate of the District is of extreme type. It is dry except during monsoon. There are large varieties of day and night temperature. The summer seasons starts from the beginning of March. May is the hottest month when the maximum temperature is about 45° C (82°F). The temperature drops down with the onset of monsoon towards the second week of June and throughout the monsoon the weather remains cool. December is the coldest month, as the mean daily minimum temperature is recorded at 11 degree C. Relative humidity is generally higher from June to December. It's varies from 27% to 70%.

The average annual rainfall of the **district** is **1378.20 mm** whereas the average annual rainfall of the **state** is **1502.5mm**. Nearly 86% of the annual rainfall is contributed by the southwest monsoon. The variation in the rainfall from year to year is not large. The monsoon starts late in June and generally lasts up to September. 90% of the rainfall received from June to September. August is the month with more number of rainy days. About 28% of rainfall is received during this month. Drought is normal feature of this district.

3.3 Soil

The major part of the area is covered by black cotton & loam types of transported and debris soil. The thickness of the soil layer is around 2 to 5 meter.

The district has five types of soils broadly classified as below:

- The red lateritic soil which is different in phosphorus and nitrogen is found all over the district. Mostly under the feet hill and hillocks.
- Sandy loam soil is seen in Lanjigarh and of the Bhawanipatna Tehsil.
- Alluvial sandy and sandy loam soil found in the area on the river banks.



Fig.5. Black Cotton Soil



Fig.6. Loamy fertile soil

Black soil is an important soil type in the district occupying parts of Bhawanipatna, Narla, Kesinga, Dharamgarh, Golamunda and Koksara blocks. These soils are rich in potassium and nitrogen but poor in phosphorus. These soils are most favourable for cotton cultivation which is a generally draught resistant, labour intensive but a highly remunerative crop.

3.4 Agriculture

Paddy, wheat and maize are the main crops and vegetables, linseed, khesari are the other crops grown in the district.



Fig.7. Vegetable cultivation at village Kanakpur



Fig.8. Chilly and Cauliflower

4. GEOLOGY

Major part of the district is underlain by rocks belonging to Eastern Ghats group comprising granite gneiss, khondalite, charnokites and quartzites. The quaternary alluvium occurs in discontinuous pockets of river channels. The most predominant rocks occurring in the district are porphyritic granite gneiss these rocks are grey to grayish white in color. The Part of Kalahandi district, where the ground water survey work is undertaken is having undulating topography and having porphyritic granite gneiss as base rock.

5. HYDROGEOLOGY

The consolidated formation (hard rock) mainly granite gneiss, forms the main hydro-geological unit. These rocks lack primary porosity and are rendered porous and permeable by weathering and fracturing. The water yielding capacity of these rocks entirely depends on the intensity of fracturing and weathering. The ground water occurs in phreatic condition in the weathered zone and under semi- confined to confined condition in deeper fracture zones.

Groundwater occurrences, movement and recharge to aquifers are controlled by the degree of weathering, fracture pattern, geo-morphological setup and various climatic factors. Weathered and fractured granite gneiss constitutes major aquifers in the project area. Ground water is present in the weathered and fractured granite zone above compact base of granite rock. Observations of open wells of the area shows comparatively low water level, the water is available in the upper weathered granite which could be easily trapped by digging dug wells or shallow wells.

The hydrogeological framework of the district is mainly controlled by the geological set up, rainfall distribution and the degree of secondary and primary porosities in the geological formations for storage and movement of ground water. Since major parts of the district are underlain by hard rocks of diverse lithological composition and structure, the water bearing properties of the formations also vary to a great extent. The area has undergone several phases of intense tectonic deformations which has been responsible for the development of deep seated intersecting fracture system. Hydrogeological surveys in the district reveals the lithological characteristics and the role of tectonic deformation on the occurrence and distribution of ground water reservoirs and their water bearing and water yielding properties. Lineaments formed due to tensile deformation were picked up from remote sensing studies. The structural elements mainly control the occurrence and movement of groundwater in the typical fractured crystalline basement terrain.

The major hydrogeologic units in the district can be subdivided into two broad groups:-

- (i) Areas underlain by fractured, fissured and consolidated basement rock formations.
- (ii) Areas underlain by recent unconsolidated alluvial formations.

Water bearing properties of the consolidated formations: The crystalline rocks like porphyritic granite gneisses, khondalites, charnockites, quartzites, which are devoid of primary porosity, occupy about 95% of the area of the district. The weathered residuum and jointed & fractured portion of these consolidated rocks constitute principal water bearing formations. The thickness of the weathered zone is generally more in the topographic low

and undulating plains than in the high land area. Ground water occurs under phreatic condition in the weathered zone and in semi-confined to confined condition in deeper fractured zones. The water yielding capacity of fractured rocks largely depends on the extent of fracturing openness and size of fracture and nature of their interconnections.

Granites and Granite Gneisses: These are the most predominant rock types in the district occupying undulating terrain and topographic low. On weathering these rocks yield sandy residuum and the intensity of weathering is controlled by the presence of open joints and foliations. Joints and fractures are well-connected creating free circulation of ground water. In general these rocks can sustain yield between 3 and 18.6 lps depending on topographic setting, thickness of weathered residuum, number of saturated fracture zones encountered and their interconnection as inferred from the ground water exploration carried out by CGWB in the district. The weathered zones in the granite gneisses can be developed through open wells and bore wells.

Khondalites: The Khondalites, in general occupy the hills and have limited ground water development potentials except when they occupy low laying areas. Due to well-foliated nature of these rocks, weathering is quite deep in low laying areas. These rocks are also well jointed. In the pediment areas, the thickness of weathering is varying from 5 to 32m. These rocks generally form steep linear ridges hence don't form potential aquifers. The thickness of the weathered zone ranges from 12 to 20 m. Ground water development potential of these rocks is meagre except in low laying areas. The specific capacity of the dug wells ranges from 2.3 to 13.3 lpm/m. The yield of the bore wells ranges from 1 to 5 lps as revealed by the ground water exploration carried out by CGWB in the district.

Charnockite: In these rocks weathering is not pronounced and foliations and joints are not well developed. These rocks are mostly hard, compact and massive. Due to paucity of joints and fractures the thickness of weathering in these formations is limited. The thickness of weathered zone ranges from 6 to 10 m. Due to hard and compact nature of the rocks ground water development prospects in the charnockite is not good and the yield from the bore wells is very poor.

Pegmatite and Quartz veins: These are coarse grained and hard. These form good aquifers when fractured and friable.

Gabbro – Anorthosites: The rheologic property of these rocks resembles with charnockite, Barring few locations dismal weathering and lack of fracturing renders these formation as a bad water yielder. The Sp. Capacity of dug wells in anorthosite vary from 16 to 102 lpm/m drawdown.

Quartzites: This unit also less fractured and weathered hence do not form good aquifers. However fractured quartzites along lineaments yield good amount of water.

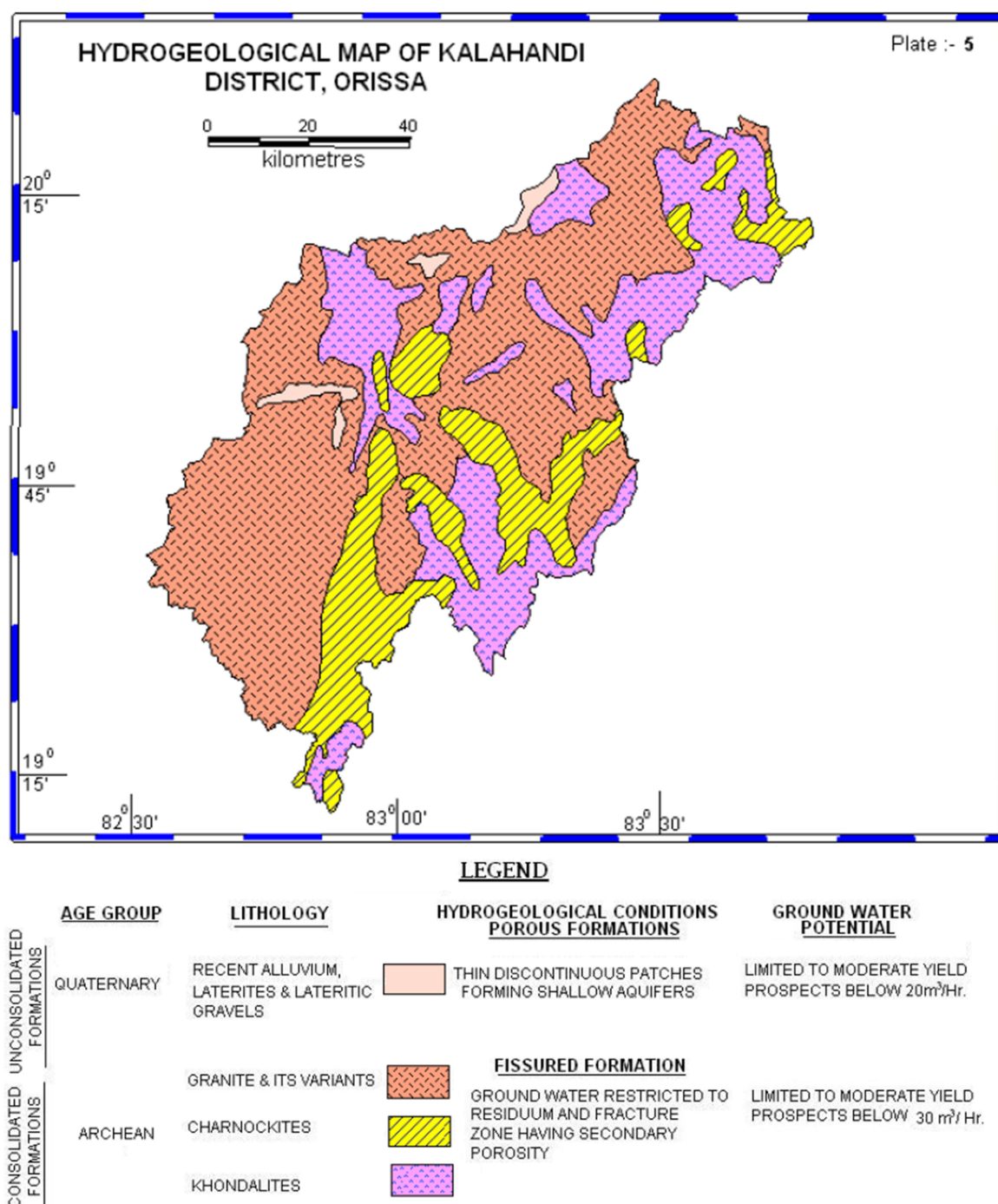
Pegmatite and quartz vein: These are coarse grained intrusives and form good aquifers when fractured.

Water bearing properties of the unconsolidated Formation: Laterites belonging to the Pleistocene age and alluvium of Sub-recent to Recent age constitute the unconsolidated formations in the district.

Laterites and lateritic gravels: Laterites of both high and low level environments occur extensively in the district forming capping over the older formations. Laterites occurring as capping over older formations are vesicular, ferruginous and highly porous in nature and at places form good near surface aquifers to be tapped through dug wells. Ground water generally occurs under phreatic condition in the shallow zone.

Alluvial deposits: The alluvial sediments of recent origin occur as thin discontinuous patches along the prominent drainage channels and form prolific aquifers under favourable conditions. Of particular interest are the alluvial deposits occurring as discontinuous patches in the flood plains of major rivers such as Tel, Udanti, Ret and the alluvial fan deposits in Indravati, Nagavalli and Vansadhara sub basins. The thickness of alluvial deposits varies from 10 to 30 m in the Indravati and Tel sub basins. These mainly consist of silt, sand with gravel and clay and form potential shallow aquifers. Ground water occurs under phreatic condition and the water table lies at shallow depths. These deposits are very suitable for ground water development through dug wells and shallow tube wells. Yield of tube wells in the alluvium varies from 5 to 10 lps for drawdown ranging from 5 to 8 m.

Aquifer Characteristics of Crystalline: In the hard crystalline rock recharge of ground water from precipitation or seepage from surface water bodies percolate into the weathered (saprolite) zone. In case the 8 underlying basement rocks (both weathered and fresh) are incised by open fractures, the downward movement of the water from the upper regolith zone (comprising the top soil and saprolite horizon) is facilitated. In the saprolite/ regolith horizon ground water generally occurs under unconfined condition where as in the fractured bedrock aquifers it occurs under semi-confined to confined conditions. The ground water potentials of various zones i.e. saprolite (tapped by dug wells), weathered basement rock and shallow fractured basement rock horizon (tapped by the hand pumps) and deeper fractured basement rock (tapped by the deep boreholes by CGWB) vary considerably depending upon their lithological and structural characteristics.



5.1 Groundwater Utility:

IM-II Hand Pumps are commonly used for utilization of groundwater source, available in the project area. Depth of dug wells varies between 20-30 ft b.g.l, in some villages has been observed. The depth of water level varies between 15-35 ft. b.g.l in the well and depleted day by day. In this case the deep well Hand Pumps are the suitable measure to utilize groundwater for drinking purpose.



Fig.9. Dug well used for irrigation purpose



Fig.10. Drip Irrigation by community for saving water



Fig.11. Hand pump - used for drinking water



Fig.12. Irrigation bore well, 1hp Submersible pumps with 1.25" delivery pipe

5.2 Water resource:

A natural stream is flowing from the hill to valley region in the area. A waterfall is also flowing in the village area 6 km away from Kinkhola village.

5.3 Ground Water Related Issues and Problems:

Ground Water Depletion is the major problem. Some of the Hand Pump fails to extract water in the summer due to depletion of groundwater. In some village area fluoride contamination is also analyzed.

5.4 Recharge of Groundwater:

To maintain the ground water table of the area, artificial recharge system, Roof Top Rain Water Harvesting, Innovative Recharge pit structures etc. can be applied. This artificial recharge will also help in increase in storage and also in improving the quality of water etc. The most feasible artificial recharge and rain water harvesting structures are percolation tanks, nala/contour bunding, small check dams/weirs, renovation of old tanks to percolation tanks, subsurface dykes, water spreading, gully plugging, gabion structures etc.

5.5 Scope of Ground Water Development:

Table1. Stage of Ground Water Development, as on 31st March, 2009, CGWB (in ha m)

Sl	Assessment Unit/	Net Annual Ground Water Availability	Existing Gross Ground Water Draft for irrigation	Existing Gross Ground Water draft for domestic and industrial Water Supply	Existing Gross Ground water draft for all uses	Allocation for domestic and industrial requirement supply up to next 25 years	Net Ground Water availability for future irrigation Development	Stage of Ground Water Development $\{(6/3) * 100\} \%$
1	2	3	4	5	6	7	8	9
1	Bhawanipatna	6412	1358	529.00	1887	1204	3850	29.43

TECHNICAL INTERVENTION BY AFPRO:

6. HYDRO-GEOLOGICAL INVESTIGATION:

The hydro-geological investigation includes the observation of local geological set-up and the Hydro geological properties of rocks such as recharge rate; well yielding capacity; pre monsoon and post monsoon fluctuations; behavior of wells; attitude of rock formations, folds, faults, joints, lineation and foliation patterns, thickness of over burden; etc are taken into consideration.

6.1. Well Inventory Data

Depth of water level in open wells varies between 3 m to 10m b.g.l. Different hydro geological and litho-logical strata found in different villages. The well inventory data indicates the moderate yield of ground water condition and recharge of the area. Water quality testing is required time to time for safe drinking water.

Table 2. Pre mon - post mon water level data

BLOCK_NAME	LATITUDE	LONGITUDE	SITE_NAME	PRE MON Water_Level	POST MON Water_Level
LANJIGARH	19°49'2" N	83°25'55" E	Biswanathppur	8.45	4.25
BHAWANIPATNA	19°51'57" N	83°9'32" E	Attanguda	6	1.74
BHAWANIPATNA	19°55'39" N	83°6'50" E	Malgaon	6	1.78
BHAWANIPATNA	19°49'0" N	83°7'15" E	Dalguma	10.3	6.2
BHAWANIPATNA	20°3'46" N	83°6'24" E	Karlapada	4	
LANJIGARH	19°51'10" N	83°25'15" E	Pokaribandh	4.5	1.35
LANJIGARH	20°3'45" N	83°22'59" E	Narla	7	5.32
BHAWANIPATNA	20°10'15" N	82°59'24" E	Sargigora	8	6.61
BHAWANIPATNA	20°1'4" N	83°9'54" E	Pastikudi1	3.2	3.65
BHAWANIPATNA	19°54'29" N	83°9'33" E	Bawanipatna	8	4.95
Source: CGWB, BBSR, Odhisa				30/04/2016	10/11/2015

7. GEOPHYSICAL INVESTIGATION:

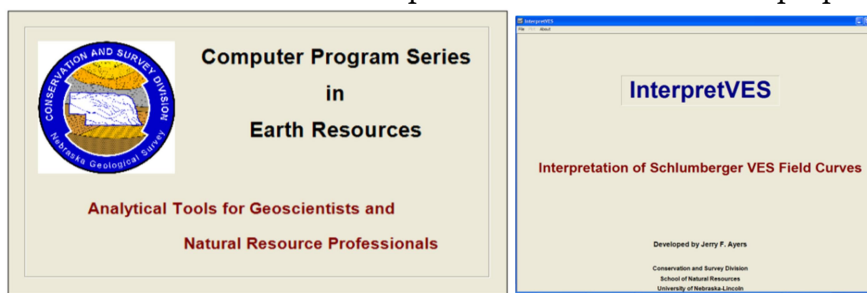
Geophysical method used in investigations was conducted by using the ABEM TERRAMETER-SAS 300B and AQUAMETER CRM-500 instrument through electrical resistivity method. The method used for investigation is “**VERTICAL ELECTRICAL SOUNDING**” by “**SCHLUMBERGER CONFIGURATION**”. In this method, the centre of the electrode spread remains fixed and the spacing between the electrodes is progressively increased until the maximum depth is reached. By way of conducting such soundings the different litho layers beneath the earth were probed to understand the thickness and apparent resistivity of different layers and its water holding capacities. It was conducted to exactly know the ground water dynamics of the area.

Electrical resistivity techniques measure earth resistivity by passing an electrical current into the ground and measuring the resulting potentials created under the earth. This method involves the supply of direct current or low-frequency alternating current in to the ground through a pair of *current electrodes* and the measurement of the resulting *potential* through another pair of electrode called *potential electrodes*. Since the current is known and the potential can be measured, an apparent resistivity can be calculated. For Schlumberger soundings, the apparent resistivity values (ρ) were plotted against half current electrode separation ($AB/2$) on a log-log graph and a smooth curve was drawn for each of the sounding. Then, the sounding curves were interpreted to determine the true resistivities and thickness (h) of the subsurface layers. The resistivity of the subsurface materials observed is a function of the magnitude of the current, the recorded potential difference and the geometry of the electrode array used. The depth of penetration is proportional to the Schlumberger array which uses closely spaced *potential electrodes* and widely spaced *current electrodes*. In general, the depth of infiltration is small in this method and only shallow subsurface layers have been surveyed.


A total number of 19 Vertical Electrical Sounding (VES) with maximum *current electrode* spacing 110m were used in order to evaluate the geo-electrical setting of the project area. The *potential electrode* spacing was probe to maximum 20m.


7.1. Interpretation of field data:


The field data are plotted in bi-logarithmic graph sheets and are matched with standard curves using partial curve matching techniques to derive the data of water bearing formation. The bi-logarithmic graph sheets is used to interpret and to draw profiles of electrical soundings, including of data extracted from resistivity tomography taken in the field. Interpret VES software is used to interpret the data for correlation purpose.



7.2. Details of VES (Vertical Electrical Sounding) and manual interpreted data by using bi-logarithmic graph sheets are given below:


VES No.	01 A			
Gram	Karlagoda			
Panchayat	Shankhairmal			
Village	Near house of Shyamsunder Nayak			
GPS	N 19° 58' 41.33"			
Location	E 83° 07' 55.09"			
Beneficiaries	15 Families			
VES No.01A. Interpretation by log log sheet				
Resistivity (Ohm-M)	Thickness (M)	Depth (M)	Formation	Litholog
12.46	2	-	Top soil clay	
87.22	3	2	Moist clay with pebbles	
61.5	16	5	Weathered rock saturated	
2240	-	21	Massive Hard rock granite	
Recommendations: Moderate aquifer for drinking purpose. Expected depth of drilling is at about 60±5 m.				

VES No.	01 B			
Gram Panchayat	Karlagoda			
Village	Shankhairmal			
Place	Near house of Kusha Gaud			
GPS	N 19° 58' 36.72"			
Location	E 83° 07' 49.81"			
Beneficiaries	30 Families			
VES No.01 B. Interpretation by log log sheet				
Resistivity (Ohm-M)	Thickness (M)	Depth (M)	Formation	Litholog
7	3	-	Top soil Black clay	
70	9	3	Moist clay with kankar	
400	10	12	Saturated with semi weathered rock	
	-	22	Massive Hard rock granite	
Recommendations: Moderate aquifer for drinking purpose. Expected depth of drilling is at about 60±5 m.				

VES No.	02 A	
Gram Panchayat	Kamthana	
Village	Dumal-Godampara	
Place	Near house of Shiv Pradhan	
GPS Location	N 19° 58' 13.91" E 83° 08' 41.45"	
Beneficiaries	15 Families	


VES No.02 A. Interpretation by log log sheet

A Resistivity (Ohm-M)	Thickness (M)	Depth (M)	Formation	Litholog
8.01	2		Top Soil with kankar	
40.05	4	2	Moist clay with kankar	
∞		6	Semi Weathered or unweathered porphyritic granite hard rock	
Recommendations: Poor aquifer expected for drinking purpose. Sanitary well with hand pump can be made at about 30-40' depth with 4-6 feet dia.				

VES No.	02 B	
Gram Panchayat	Kamthana	
Village	Dumal - Godampara	
Place	Near house of Shiv Pradhan	
GPS Location	N 19° 58' 14.85" E 83° 08' 41.70"	
Beneficiaries	15 Families	


VES No.02 B. Interpretation by log log sheet

A Resistivity (Ohm-M)	Thickness (M)	Depth (M)	Formation	Litholog
32.51	2		Top Soil clay with kankar	
81.27	5	2	Moist clay with kankar	
1200	3.2	7	Un weathered or massive rock	
	-	10.2		
Recommendations: Poor. Sanitary well with hand pump can be made at about 30-40' depth with 4-6 feet dia.				

VES No.	02 C	
Gram Panchayat	Kamthana	
Village	Dumal - Godampara	
Place	In land of Padman Pradhan	
GPS Location	N 19° 58' 12.78 E 83° 08' 40.13"	
Beneficiaries	15 Families	


VES No.02 C. Interpretation by log log sheet

A Resistivity (Ohm-M)	Thickness (M)	Depth (M)	Formation	Litholog
23.91	2		Top Soil clay with kankar	
119.55	8	2	Weathered rock	
410	6	10	Semi weathered to un weathered granite	
3200		16	Massive rock porphyritic granite	
Recommendations: Poor to Moderate for drinking purpose. Exp. Depth of drilling is about 45±5m. 3-6m slotted casing should be installed to tap the upper water because the groundwater is not much sufficient.				

VES No.	03	
Gram Panchayat	Kamthana	
Village	Dumal - Limpara	
Place	In land of Sana Naik	
GPS Location	N 19° 58' 30.24" E 83° 09' 07.39"	
Beneficiaries	15 Families	

VES No.03. Interpretation by log log sheet


A Resistivity (Ohm-M)	Thickness (M)	Depth (M)	Formation	Litholog
31.83	1.5		Top Soil clay with kankar	
39.78	4.5	1.5	Moist clay with kankar	
600	9	6.0	Semi weathered to Unweathered porphyritic granite	
1400	-	15	Highly hard rock massive granite	
Recommendations: Poor to Moderate. Exp. Depth of drilling is about 50±5m. Slotted casing to be installed 3-6 m to tap the sub surface water because the groundwater is not much expected.				

VES No.	04 A	
Gram Panchayat	Rishgaon	
Village	Dongripara	
Place	Near Rikhiram Manjhi house	
GPS Location	N 19° 54' 50.11" E 83° 07' 54.89"	
Beneficiaries	30 Families	

VES No.04A. Interpretation by log log sheet

A Resistivity (Ohm-M)	Thickness (M)	Depth (M)	Formation	Litholog
22.14	2		Top Soil clay with kankar	
22.14	2	2	Moist clay with kankar	
77.49	4.8	4	Weathered or fracture layer	
1660		8.4	Massive rock granite	


Recommendations: Poor to moderate aquifer for drinking purpose. Exp. Depth of drilling is about 50±5m. Slotted casing to be installed 3-6 m to tap the sub surface water because the groundwater is not much expected.

VES No.	04 B	
Gram Panchayat	Rishgaon	
Village	Dongripara	
Place	Near Mangal Manjhi house	
GPS Location	N 19° 54' 49.49" E 83° 08' 00.07"	
Beneficiaries	15 Families	

VES No.04 B. Interpretation by log log sheet

A Resistivity (Ohm-M)	Thickness (M)	Depth (M)	Formation	Litholog
26.62	2		Top Soil clay with kankar	
10.64	3	2	Moist clay with kankar	
165	10	5	Weathered or fracture rock	
930	-	15	Massive rock granite	


Recommendations: Poor to moderate. Exp. Depth of drilling is about 60±5m. Slotted casing to be installed 3-6 m to tap the sub surface water because the groundwater is not much expected.

VES No.	05	
Gram Panchayat	Kamthana	
Village	Dumal – Patelpara	
Place	Near Utkal Janni Club	
GPS Location	N 19° 58' 07.11" E 83° 08' 58.07"	
Beneficiaries	30 Families	

VES No.05. Interpretation by log log sheet

A Resistivity (Ohm-M)	Thickness (M)	Depth (M)	Formation	Litholog
17.31	2		Top soil with clay	
34.62	2	2	Moist clay with kankar	
125	12	4	Weathered or fracture rock	
574	20	16	Semi weathered to unweathered rock	
		36		


Recommendations: Moderate Exp. Depth of drilling is about 60±5m.

VES No.	06	
Gram Panchayat	Kamthana	
Village	Bhimdanga	
Place	Near house of Tebhadhar Gaud	
GPS Location	N 19° 59' 18.23" E 83° 08' 45.30"	
Beneficiaries	30 Families	

VES No.06. Interpretation by log log sheet

A Resistivity (Ohm-M)	Thickness (M)	Depth (M)	Formation	Litholog
12.25	2		Top soil with clay	
61.25	10	2	Moist clay with kankar	
690	10.5	12	Semi weathered to unweathered rock	
		22.5		

Recommendations: Poor to Moderate Exp. Depth of drilling is about 60±5m.

VES No.	07	
Gram Panchayat	Thuapadar	
Village	Talpara	
Place	Near house of Rajendra Naik	
GPS Location	N 19° 58' 56.59" E 83° 11' 35.44"	
Beneficiaries	30 Families	

VES No.07 Interpretation by log log sheet

A Resistivity (Ohm-M)	Thickness (M)	Depth (M)	Formation	Litholog
44.46	1.5		Top soil with clay	
28.89	3.0	1.5	Moist clay with laterite kankar	
224	12	4.5	Weathered /fracture rock	
420	25	16.5	Semi weathered to unweathered rock	
		41.5		


Recommendations: Moderate Exp. Depth of drilling is about 60±5m.

VES No.	08	
Gram Panchayat	Thuapadar	
Village	Nawapara	
Place	In land of Sansera Manjhi	
GPS Location	N 20° 00' 36.38" E 83° 09' 41.37"	
Beneficiaries	30 Families	

VES No.08 Interpretation by log log sheet


A Resistivity (Ohm-M)	Thickness (M)	Depth (M)	Formation	Litholog
13.57	6		Top soil with clay	
47.49	15	6	Weathered rock saturated	
∞	3.7	21	Massive hard rock	
		24.7		

Recommendations: Poor to Moderate Exp. Depth of drilling is about 60±5m.

VES No.	09	
Gram Panchayat	Thuapadar	
Village	Kusumkhunti	
Place	Near house of Padmanabho Gaud	
GPS Location	N 19° 59' 09.95" E 83° 09' 47.96"	
Beneficiaries	30 Families	


VES No.09. Interpretation by log log sheet

A Resistivity (Ohm-M)	Thickness (M)	Depth (M)	Formation	Litholog
11.64	4.0		Top soil with clay	
40.74	4.8	4	Weathered rock saturated	
345	5.5	8.8	Semi weathered rock	
280	18	14.3	Weathered / fractured rock	
		32.3		
Recommendations: Moderate to Good Exp. Depth of drilling is about 60±5m.				

VES No.	10	
Gram Panchayat	Thuapadar	
Village	Kusumkhunti	
Place	Near house of Narendra Harizan	
GPS Location	N 19° 59' 09.95" E 83° 09' 47.96"	
Beneficiaries	30 Families	

VES No.10. Interpretation by log log sheet


A Resistivity (Ohm-M)	Thickness (M)	Depth (M)	Formation	Litholog
12.97	3.0		Top soil with clay	
90.79	7.5	3	Weathered soil with rock kankar	
315	18	10.5	Weathered / Semi weathered rock	
		28.5		
Recommendations: Moderate to Good Exp. Depth of drilling is about 60±5m.				

VES No.	11	
Gram Panchayat	Karlagoda	
Village	Borguda	
Place	Near house of Prasann Kr. Chinda	
GPS Location	N 20° 01' 17.84" E 83° 07' 50.79"	
Beneficiaries	30 Families	

VES No.11 Interpretation by log log sheet

A Resistivity (Ohm-M)	Thickness (M)	Depth (M)	Formation	Litholog
42.32	1.5		Top soil with kankar	
52.9	3.7	1.5	Weathered soil with rock kankar	
78	15	5.2	Weathered rock with saturation	
504	20	20.2	Semi weathered to hard rock	
		40.2		


Recommendations: Good Exp. Depth of drilling is about 60±5m.

VES No.	12	
Gram Panchayat	Lakhimpur	
Village	Lakhimpur	
Place	Near house of Some Mahali	
GPS Location	N 19° 53' 57.03" E 83° 11' 56.12"	
Beneficiaries	30 Families	

VES No.12 Interpretation by log log sheet

A Resistivity (Ohm-M)	Thickness (M)	Depth (M)	Formation	Litholog
30.89	1.5		Top soil with lateritic kankar	
77.22	0.9	1.5	Weathered soil with laterite kankar	
9.6	7.2	2.4	Loose clay with saturations	
75	12	9.6	Weathered rock with saturation	
390	15	21.6	Semi weathered to hard rock	
		36.6		

Recommendations: Good Exp. Depth of drilling is about 60±5m.

VES No.	13	
Gram Panchayat	Medinipur	
Village	Jaganathpur	
Place	Near house of Sujit Naik	
GPS Location	N 19° 55' 40.77" E 83° 12' 39.99"	
Beneficiaries	30 Families	


VES No.13 Interpretation by log log sheet

A Resistivity (Ohm-M)	Thickness (M)	Depth (M)	Formation	Litholog
54.71	3		Top soil with clay	
27.35	18	3	Weathered soil with saturation	
101.5	14	21	Weathered fractured rock with saturation	
399		35	Semi Weathered to hard rock	
Recommendations: Good Exp. Depth of drilling is about 60±5m.				

VES No.	14	
Gram Panchayat	Kamthana	
Village	Borbhatta	
Place	Near house of Shishu Naik	
GPS Location	N 19° 56' 50.03" E 83° 07' 44.18"	
Beneficiaries	30 Families	

VES No.14 Interpretation by log log sheet

A Resistivity (Ohm-M)	Thickness (M)	Depth (M)	Formation	Litholog
6.98	2		Top soil with clay	
8.72	2	2	Moist soil with clay	
28	12	4	Weathered / Fracture rock	
420	6	16	Semi weathered to hard rock	
		22		
Recommendations: Good Exp. Depth of drilling is about 60±5m.				

VES No.	15 Correlation Purpose	
Gram Panchayat	Kamthana	
Village	Dumal	
Place	Existing New installed Hand Pumps	
GPS Location	N 19° 58' 42.77" E 83° 08' 53.71"	
Beneficiaries	10 Families	

VES No.15 Interpretation by log log sheet

A Resistivity (Ohm-M)	Thickness (M)	Depth (M)	Formation	Litholog
79.14	3		Top soil with kankar	
118.71	3	3	Weathered rock	
28.2	15	6	Highly weathered/fracture with saturation	
570	10	21	Semi weathered to Hard rock	
		31		
Recommendations: Good Yield. Depth of drilling is being done at 60 m.				

7.3. Technical Findings: According to the results of the resistivity survey carried out in the project area, the geo-electrical pseudo-sections analysis is now reach to the following conditions:

- The resistivity values were decreased towards the center of the area due to decreasing grain size, pores and permeability of the strata.
- The low resistivity anomalies were extended in the middle depth of geo-electrical sections under the ground due to influence of groundwater.
- The resistivity values were increased in more depth due to presence of massive bed rock with high resistivity.
- The lowest resistivity values were observed in weathered fractures or saturated zones.
- The 1st layer was interpreted to be near surface layer and had highly variable resistivity ranges. The 2nd layer was dry weathered layer with kankar, pebble formation with thickness of more than surface layer. The 3rd geo-electrical layer that corresponded to the weathered / fracture saturated layer having resistivity range between 80-400 Ω m. The 4th layer becomes bedrock massive hard granite and some time it may also be semi weathered or fracture condition. 5th layer becomes massive hard bed rocks with very high resistivity range more than 400 Ω m where no aquifer is encountered under the strata.
- The Study area comes under *moderate groundwater provenance*.
- Groundwater aquifer occurs under water table /semi confined and unconfined conditions
- The weathered and fractured granite gneiss formation forms the main water bearing zones in the area.
- Recharge of groundwater source is low and runoff is high because of undulating topography of the area.
- Based on the analysis of the Geo-electric curves, groundwater resources of the investigated area are not much satisfactory and not guaranteed for the muddy-slush (sludge) and pebbly sandstone of collapsible zone below the underground water bearing rock strata.

8. RECOMMENDATIONS: Based on the above hydro-geological investigation and geophysical survey & data interpretation, following recommendation rendered for drilling installation of Tube Well for drinking purpose.

Table 3. Recommendations						
SL	VES No.	Gram Panchayat	Village	Location/Place	Remarks	Exp. Depth of Drilling (m)
1	1A	Karlagoda	Shankhairmal	Near house of Shyamsunder Nayak	Mod	60±5
2	1B	Karlagoda	Shankhairmal	Near house of Kusha Gaud	Mod	60±5
3	2A	Kamthana	Dumal-Godampara	Near house of Shiv Pradhan	Poor	-
	2B	Kamthana	Dumal-Godampara	Near house of Shiv Pradhan	Poor	-
	2C	Kamthana	Dumal-Godampara	In land of Padman Pradhan	Poor to Mode	45±5
4	3	Kamthana	Dumal - Limpara	In land of Sana Naik	Poor to Mode	50±5
5	4A	Rishgaon	Dongripara	Near Rikhiram Manjhi house	Poor to Mode	50±5
	4B	Rishgaon	Dongripara	Near Mangal Manjhi house	Poor to Mode	60±5
6	5	Kamthana	Dumal – Patelpara	Near Utkal Janni Club	Mode	60±5
7	6	Kamthana	Bhimdanga	Tebhadhar Gaud	Poor to Mode	60±5
8	7	Thuapadar	Talpara	Near house of Rajendra Naik	Poor to Mode	60±5
9	8	Thuapadar	Nawapara	In land of Sansera Manjhi	Poor to Mode	60±5
10	9	Thuapadar	Kusumkhunti	Near house of Padmanabho Gaud	Mode to Good	60±5
11	10	Thuapadar	Kusumkhunti	Near house of Narendra Harizan	Good	60±5
12	11	Karlagoda	Borguda	Near house of Prasann Kr. Chinda	Good	60±5
13	12	Lakhimpur	Lakhimpur	Near house of Some Mahali	Good	60±5
14	13	Medinipur	Jaganathpur	Near house of Sujit Naik	Good	60±5
15	14	Kamthana	Borbhatta	Near house of Shishu Naik	Good	60±5

8.1 Suggestions:

Overall observation is confined that no any site is best feasible for supply of water for irrigation purpose. The only drinking purpose can be solved by these bore wells.

- Drilling is feasible at a distance of ½ to 1m average dia. from survey point.
- 4 ½ or 5 inch dia. And an on average 60±5 metre depth bore hole should be drilled at recommended sites by DTH drilling techniques. Flushing is necessary time to time due course of drilling. Casing should be installed against loose soil and highly weathered zone at 15-20m approx. In case of collapsible zone observed, slotted

casing should be extending up to hard rock formation. Slight variation is possible in depth of drilling and installation of casing depending upon weathered/fracture lithological formation and findings of good aquifer under the strata.

- The result cannot be guaranteed in case of underground folding, faulting, tilting and collapsible zone (muddy sludge strata); however in this type formation good aquifer can be found.
- Pumping test is required to know about the exact yield (lph/lpm) of ground water from drilled bore well or it may be observed during drilling.
- Water quality testing should be done before consuming the water in these areas because of acidic/basic nature of water quality.
- According to Geological and Hydro-geological strata under the crustal earth the occurrence of groundwater is not in very good condition and the groundwater table level goes down day by day due to overexploitation. To manage the groundwater table level groundwater recharging through roof water harvesting structures and other innovative techniques can be apply.
- Follow Annexure for VES Graphs interpreted manually.

- *Though due care has been taken in conducting groundwater survey, results cannot be guaranteed as this is an indirect method of subsurface investigation.*